Kirchhoff's Laws

Junction Law or the Current Law

Current into a junction = current out

series $I=I_1=I_2$

Loop Law or Voltage Law

V around Loop adds to Zero

Series

$V = V_1 + V_2$

parallel $I=I_1+I_2$

Parallel

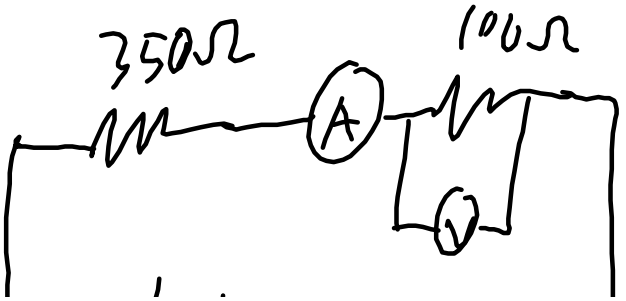
$V = V_1 = V_2$

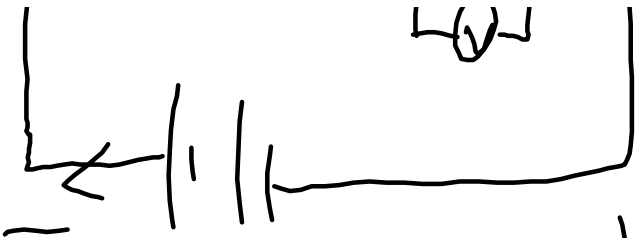
Determine the voltage across, current through and power output of each resistor when they are

a) in series with each other

b) in parallel with each other

Draw a circuit diagram showing an ammeter and voltmeter connected to the 100 ohm resistor.





I 6V $\quad I = \frac{V}{R_T} = \frac{6.0V}{350\Omega + 100\Omega}$

$= 13.3 mA$

$V_{350} = IR = 350\Omega \times 13.3 \times 10^{-3} A$

$= \boxed{4.67V}$

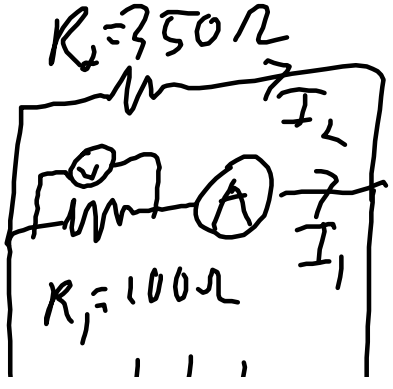
$V_{100\Omega} = 100\Omega \times 13.3 \times 10^{-3} = \boxed{133V}$

$P_{350\Omega} = I^2 R = (13.3 \times 10^{-3})^2 (350$

$= \boxed{62.2 mW}$

$P_{100\Omega} = \boxed{17.8 mW}$

b)



$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

V

$$I = \frac{V}{R_T}$$

I $V = 6.0V$

$V = 6.0V = V_1 = V_2$

$I_1 = \frac{V_1}{R_1} = \frac{6.0V}{100\Omega} = 0.060A$

60mA

$I_2 = \frac{6.0V}{350\Omega} =$ 171mA

$P_1 = \frac{V^2}{R} = \frac{6^2}{100} =$ 360mW

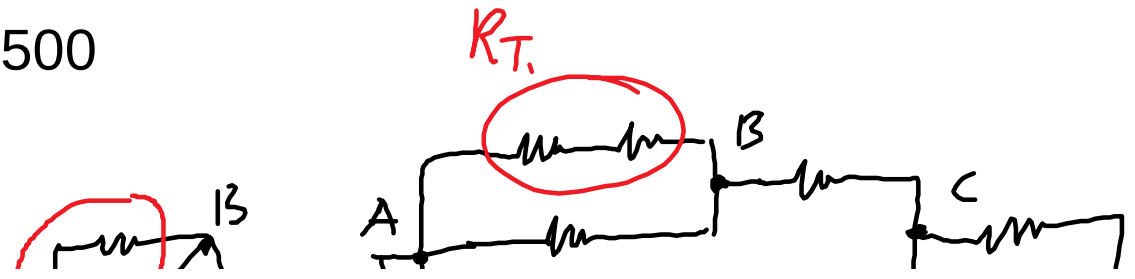
$P = VI$

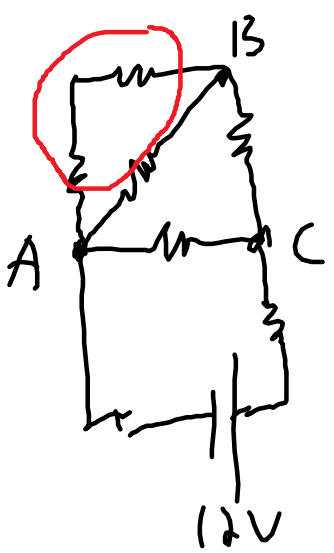
$I = \frac{V}{R}$

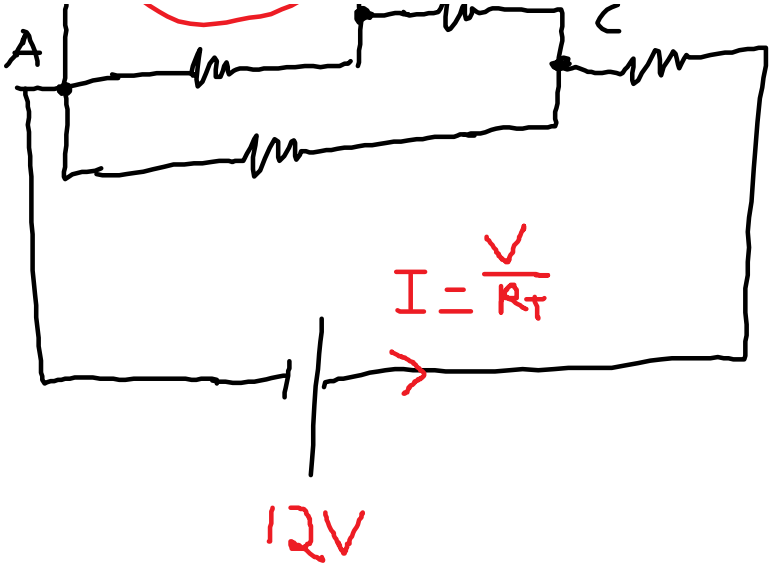
$P_2 = \frac{6^2}{350} =$ 103mW

$P = I^2 R$

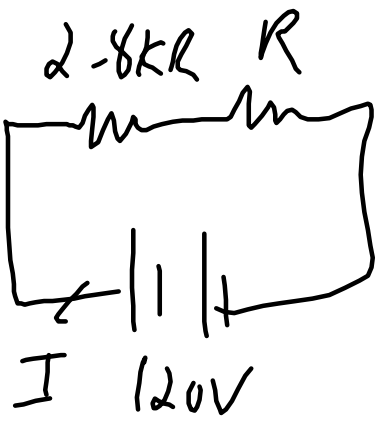
Q5 p 500







Q 9



P_1 P_2

$$P_1 = \frac{1}{4} P_2$$

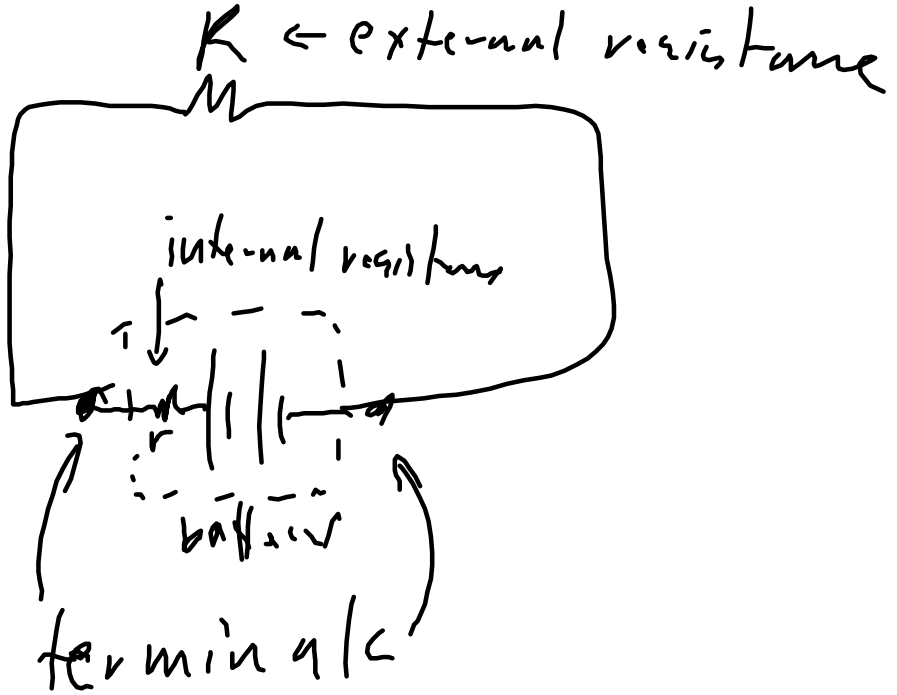
Read Lab p85-89
P500 Q13-17, keeners 21-27

Internal Resistance, r

Power supplies and batteries lose

some energy as heat. We model this loss as being like a resistor inside the battery/power supply.

Look for this in the lab next class:



$\mathcal{E}mf$ - Voltage with no loss
- No current

V_T - Terminal voltage
- Voltage with current

$$V_T = \mathcal{E}mf - Ir$$

if charging the battery

change the -Ir to +Ir

A 1.5 V battery is connected to a 4.0 ohm external resistance. If the current through the resistor is only 0.30 A, what is the

a) terminal voltage

b) internal resistance

P499 Q1-11odd doublecheck

P500 Q13-17 odds - keeners - 21-27

εmf = 1.5V - measured with no current

a) $V_t = RI = 4 \times 0.30 = 1.2$ V

b) $V_t = \varepsilon mf - Ir$

$1.2V = 1.5V - (0.30A)r$

$0.3V = 0.3A\ r$

$r = 1.0\Omega$

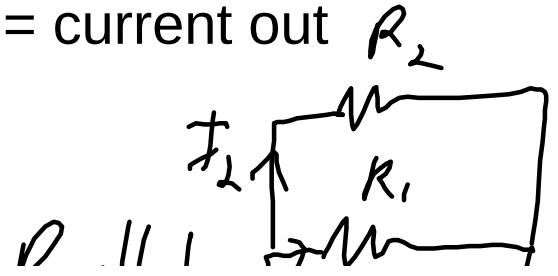
Current Electricity - Internal resistance

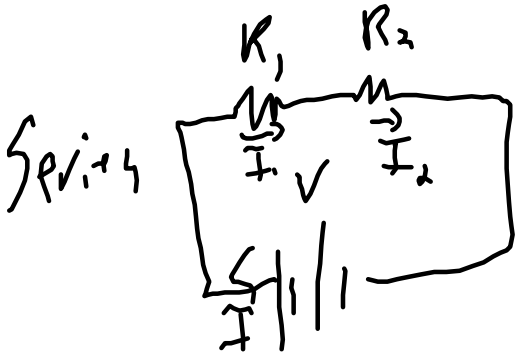
Kirchhoff's Laws:

1. Loop Law or Voltage Law
   - voltages around a loop add to zero.
   - series $V=V_1+V_2$
   - parallel $V=V_1=V_2$
2. Junction Law or Current Law
   - current into a junction = current out

series $I=I_1=I_2$

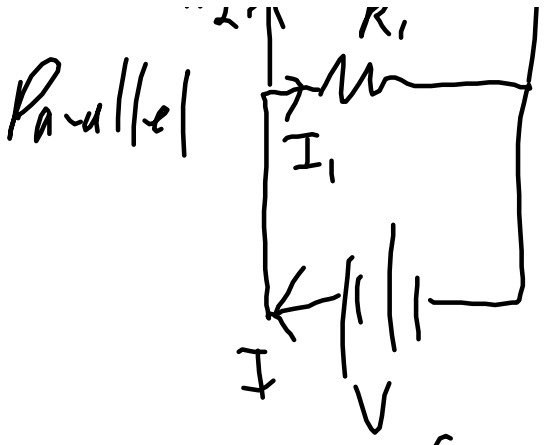
parallel $I=I_1 + I_2$





$V = V_1 + V_2$

$I = I_1 = I_2$



$V = V_1 = V_2$

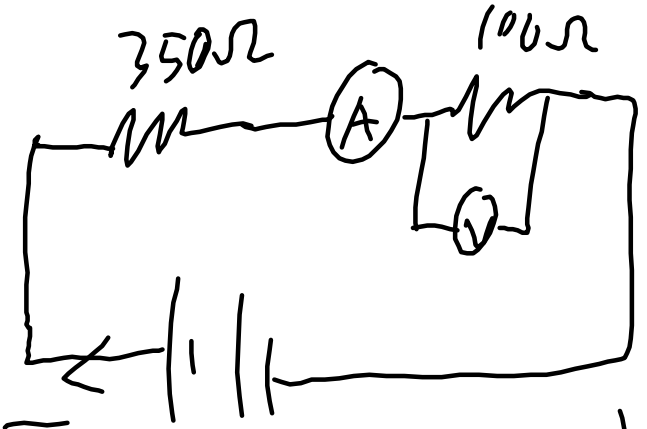
$I = I_1 + I_2$

Determine the voltage across, current through and power output of each resistor when they are

a) in series with each other

b) in parallel with each other

Draw a circuit diagram showing an ammeter and voltmeter connected to the 100 ohm resistor.



$I = \frac{V}{R_T} = \frac{6.0\,V}{350\,\Omega + 100\,\Omega}$

$= 13.3\,mA$

$V_{350} = I R = 350\,\Omega \times 13.3\,mA$

$V_{350\Omega} = 13.3 \times 10^{-3} \times 350 = 4.67\,V$

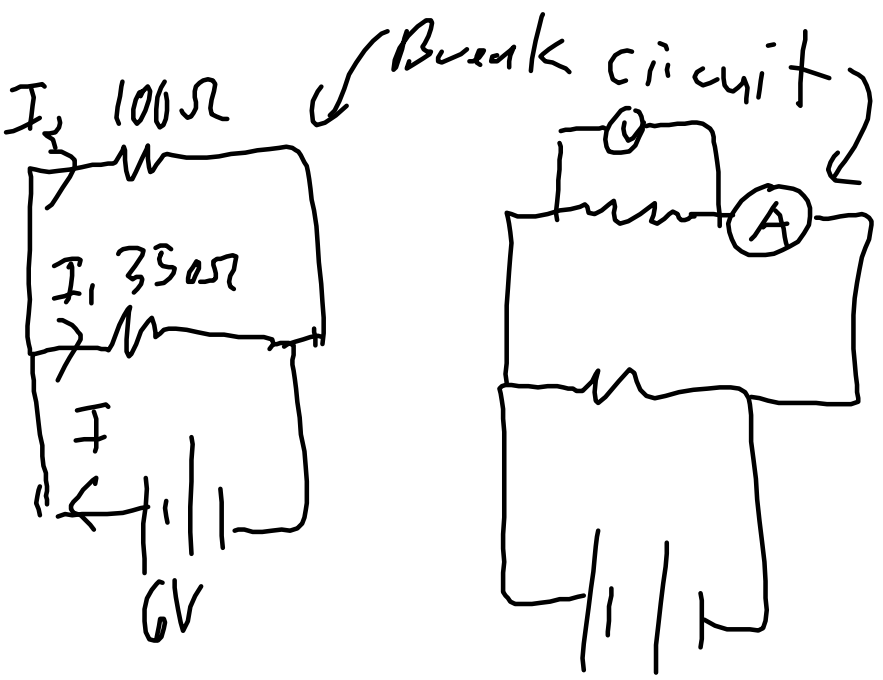
$V_{100\Omega} = 100\,\Omega \times 13.3 \times 10^{-3} = 1.33\,V$

$P_{350\Omega} = I^2 R = (13.3 \times 10^{-3})^2 (350$

$= 62.2\,mW$

$P_{100\Omega} = 17.8\,mW$

b)



$V = V_1 = V_2 = 6\,V$

$$I_1 = \frac{V_1}{R_1} = \frac{6V}{350\Omega} = 17.1mA$$

$$I_2 = \frac{V_2}{R_2} = \frac{6V}{100\Omega} = 60mA$$

$$P_1 = \frac{V^2}{R} = \frac{6^2}{350} = 0.103W$$

$$P_2 = \frac{6^2}{100} = 0.36W$$

Internal Resistance

Have you noticed that when you run a battery with lots of current, it gets hot. Some of the energy is dissipated as heat inside the battery before going to the outside.

We can model this as being like a resistor (dissipate electrical energy as heat) inside the battery or power supply, the internal resistance.

eg. When we connected two 10.0 ohm resistors in series with a 6.0 V battery, the voltage across the battery (terminal voltage, V_t) dropped to 5.5V. What is

a) current through the two 10.0 ohm resistors?
I=terminal voltage/external resistance= V_t/R
=5.5V/(10+10 Ω)= 0.28 A

b) the internal resistance of the battery, r?

the Emf is the electromotive force, the voltage of the battery with no current (no energy lost).
Emf = 6.0V
V_t =5.5V

$V_t = emf - Ir$

\+ when you are charging the battery,

5.5V = 6.0V - 0.275A x r
r= 0.5/0.275=1.8182
the internal resistance, r = 1.8Ω

Homework: Quiz April 12
double check Q1-11 odds
read the lab p85-89 bring labbook.
p500 Q13-17 odds - keeners 21-27

Current Electricity
review:

Kirchhoff's Laws

1. Loop Law or Voltage Law
   Voltages around a loop add to zero.
   series circuit example - $V=V_1+V_2$
   parallel $V=V_1=V_2$

   2. Junction Law or Current Law
   Current into a junction = Current out
   series circuit - $I=I_1=I_2$
   parallel $I=I_1 + I_2$

   Determine the voltage across, current through and power output of each resistor when they are
   a) in series with each other
   b) in parallel with each other
   Draw a circuit diagram showing an ammeter and voltmeter connected to the 100 ohm resistor.